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13. ABSTRACT (Maximum 200 words)

For the reported period I, Dr. Yu. Godin, Dr. I. Khalfin and Dr. V. Gorentsveig worked on the problems on the band-gap structure of 2D and 3D photonic crystals and the localization of electromagnetic and acoustic waves in periodic media and in media with single defects:

1. The model and time efficient code for the computation of the optimal parameters for the 2D photonic crystals have been developed. The results of the work have been used to compute the optimal design parameter of 2D photonic crystals for Dr. L. Webb and Dr. G. Sullivan from Boeing (former Rockwell). An asymptotic model of 3D photonic crystals has been developed and we has begun its computer implementation.

2. The mathematical theory of cavity eigenmodes has been extended to the case of electromagnetic and acoustic waves. We have also developed algorithms based on the lattice models for the computing of localized classical waves generated by defects in the background periodic media. The algorithms have been implemented in a code which demonstrated all expected phenomena including tunneling. It also gives an estimation of the localization radius of a cavity eigenmode. The code produces also nice graphical images of the cavity eigenmodes and spectra.

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"Spectral Properties of Periodic and Disordered Dielectric and Acoustic Media"

A. Figotin

Decemeber 1998

For the reported period I, Dr. Yu. Godin, Dr. I. Khalfin and Dr. V. Gorentsveig worked on the problems on the *band-gap structure* of 2D and 3D Photonic Crystals and the *localization* of electromagnetic and acoustic waves in periodic media and in media with single defects.

- **Computations of spectra of periodic structures.** The emphasis of the joint work with Dr. Yuri Godin for the reported period was the refinement of the code and the computation of the optimal parameters for the 2D photonic crystals. That work was accomplished and we can give the parameters for 2D photonic crystals of the square structure that will produce the largest possible gaps. The square periodic structure is the easiest to fabricate. Dr. L. Webb and Dr. G. Sullivan from Boeing (former Rockwell) Inc. have fabricated those periodic structures of different dimensions. Today not only we can find the spectrum of a given photonic crystal of the square geometry but we can recommend the best structure to be fabricated under given constrains. As far as 3D structures are concerned we have developed a few algorithms for the computation of the spectral attributes. I have ordered a powerful SGI computer funded by AFOSR and expect to start the implementation of one or , may be, two of those algorithms soon.

- **Localized eigenmodes in a cavity.** Working jointly with Dr. Igor Khalfin we have developed algorithms based on the lattice models for the computing of localized classical waves generated by defects in the background periodic media. The algorithms have been implemented and we have the code which can handle an arbitrary lattice defect. The code demonstrated all expected phenomena including tunnelling, and it gives an estimation of the localization radius of a cavity eigenmode. The code produces also nice graphical images of the cavity eigenmodes and spectra. Now Dr. Vladimir Gorentsveig continues the work on the localization phenomenon in the cavities. He learned our recent results with Dr. A. Klein on the midgap cavity eigenmodes and is working on the algorithm of their computation.

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The results of the work have been reported at:

- NATO Advanced Studies Institute, Les Houhces, France, *Diffise Waves in Complex Media, Spectra of Photonic Crystals*, March 1998.

- Electromagnetics Workshop, Brooks Air Force Base, San Antonio, *Spectral properties of Classical Waves in High Contrast Periodic Media, Tunable Photonic Crytals* , January 1998.

- AMS Meeting, Albuquerque, *Spectral Properties of Classical Waves in High Contrast Periodic Media*, November 1997.

- Progress in Electromagnetics Research Symposium - PIERS 97, Cambridge, MA, *Bound States of a One-band Model for 3D Periodic Medium*, July 7 -11, 1997.

- Solid State Seminar, University of California at Irvine, *Midgap Defect Modes in Lossless Dielectrics*, June 1997.

- Mathematical Physics Seminar, University of California at Irvine, *The Computation of Spectra of Some 2D Photonic Crystals*, June 1997.

- AFOSR Workshop on Functional Meso-Optics, Crested Butte, Colorado, *Localization of Electromagnetic Waves*, January 1997.

- Electromagnetics Workshop, Brooks Air Force Base, San Antonio, *Computation of spectra of 2D photonic crystals* , January 1997.

- International Conference, University of Insbruck, Institute of Physics and Meteorology, Austria, *Anderson Localization of Classical Waves*, July 1996.

- Statistical Mechanics Conference, Rutgers University, New Brunswick, *Bands and Gaps in the Spectra of Periodic Dielectric and Acoustic Media*, May 1996.

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PAPERS PUBLISHED

[1] *Band-Gap Structure of the Spectrum of Periodic Dielectric and Acoustic Media. I. Scalar model*, SIAM Journal on Applied Mathematics. **58**, pp. 68-88, (1996), (with P. Kuchment)

[2] *Band-Gap Structure of the Spectrum of Periodic Dielectric and Acoustic Media. II. 2D Photonic Crystals*, SIAM Journal on Applied Mathematics. **56**, No. 6, pp. 1561-1620, (1996), (with P. Kuchment)

[3] *2D Photonic Crystals with Cubic Structure: Asymptotic Analysis*, in "Wave Propagation in Complex Media", IMA Proceedings **96**, G. Papanicolaou, ed., Springer-Verlag, pp. 23-30, (1997), (with P. Kuchment).

[4] *Localization of Classical Waves I. Acoustic Waves*, Communications in Mathematical Physics, **180**, pp. 439-482, (1996), (with A. Klein).

[5] *Localized Classical Waves Created by Defects*, Journal of Statistical Physics, **86**, pp. 165-177, (1997), (with A. Klein).

[6] *Localization of Classical Waves II. Electromagnetic Waves*, Communications in Mathematical Physics, **184**, pp. 411-441, (1997), (with A. Klein).

[7] *The computation of spectra of some 2D photonic crystals*, Journal of Computational Physics, **136**, pp. 585-598, (1997), (with Yu. Godin).

[8] *Bound states of a one-band model for 3D periodic medium*, Journal of Computational Physics, **138**, pp. 153-170, (1997), (with I. Khalfin).

[9] *Midgap Defect Modes in Dielectric and Acoustic Media*, SIAM Journal on Applied Mathematics, **58**, 6, pp. 1748-1773, (1998), (with A. Klein).

[10] *2D Tunable Photonic Crystals*, Phys. Rev. **B 57**, 5, pp. 2841-2848, (1998), (with Yu. Godin and I. Vitebsky).

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[11] *Localization of Light in Lossless Inhomogeneous Dielectrics*, Journal of the Optical Society of America **A 15**, No. 5, pp. 1423-1435, (1998) (Feature Issue on Mathematics and Modeling in Modern Optics), (with A. Klein).

[12] *Spectral properties of classical waves in high contrast periodic periodic media*, SIAM J. Appl. Math., **58**, No. 2, pp. 683-702, (1998)(with P. Kuchment).

[13] *Localized Electromagnetic Waves in a Periodic-Layered Dielctric Medium with a Defect*, Phys. Rev. **B 58**, 1, pp. 180-189, (1998), (with V. Gorentsveig).